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13SEP02 E747717-7 001063
P01/7700 0.00-0221111.8

1. Your reference — MHS.P52238GB

2. Patent application number *(The Patent Office will fill in this part)* — 0221111.8 — 12 SEP 2002

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

RF Tags Limited
Village Farm
Church Road
Weston-on-the-Green
Bicester, Oxfordshire
OX25 3QP

Patents ADP number *(if you know it)* — 08463986001

If the applicant is a corporate body, give the country/state of its incorporation — United Kingdom

4. Title of the invention — Radio Frequency Identification Tagging

5. Name of your agent *(if you have one)* — Marks & Clerk

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

4220 Nash Court
Oxford Business Park South
Oxford OX4 2RU
United Kingdom

Patents ADP number *(if you know it)* — 7271125001

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*
a) any applicant named in part 3 is not an inventor, or
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Claim *(s)*	4
Abstract	1
Drawing *(s)*	6 ~~x~~ 9

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Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	1
Request for preliminary examination and search *(Patents Form 9/77)*	1
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. I/We request the grant of a patent on the basis of this application.

Signature Marks & Clerk Date

Marks & Clerk 11 September 2002

12. Name and daytime telephone number of person to contact in the United Kingdom

Martin Hagmann-Smith 01865-397900

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RADIO FREQUENCY IDENTIFICATION TAGGING

The present invention relates to various aspects of radio frequency identification (RFID) tagging. The invention is particularly applicable to passive RFID tags, but can also be applied to powered RFID tags. In some aspects the invention relates to antenna structures for use with a RFID tag reader.

Passive RFID tag structures which operate in the UHF band (860 to 920 MHz) are known in the art. One known RFID tag structure comprises a RFID integrated circuit and a patch antenna, another known RFID tag structure comprises a RFID integrated circuit and circuitry for forming a YAGI antenna. Both are available from Bistar of Johannesburg, South Africa.

It is desirable to use passive RFID tag structures for tagging objects such as products being sold in a supermarket, animals or humans. The passive RFID tag structure can then be used, together with a tag reader, to detect the passage or presence of the tagged object, animal or human in a doorway, portal or similar. However, with currently permitted radio power levels the range of standard tag structures is 70cm or less, which limits the size of any doorway or portal.

At least in some aspects the present invention aims to increase the range of passive RFID tag structures. US 6,278,413 discloses a technique for increasing the gain of a RFID tag with driven antenna element by providing a reflector element 38 on one side of the driven antenna element 18 and a director element 36 on the other side of the driven antenna element (see for example figure 27). The driven antenna element, the reflector element and the director element are mounted on a substrate, which substrate can be folded or formed into a roll. It will be appreciated that, in particular in the folded state, this structure is prone to damage or detuning.

US 6,215,402 discloses a RFID tag structure including a patch antenna and a ground plane spaced from the patch antenna.

The present inventor has appreciated that the RFID tag structure disclosed in US 6,215,402 is relatively large, due to the fact that the ground plane is substantially larger than the patch antenna of the tag structure. Surprisingly, the present inventor has found that the ground plane does not need to be substantially larger than the patch antenna without significant loss of range.

In a first aspect the present invention provides a Radio Frequency Identification (RFID) tag antenna structure comprising: a patch antenna; and a ground plane spaced from the antenna, wherein the area spanned by the ground plane is not substantially larger than the area spanned by the patch antenna.

Due to its reduced size the RFID tag structure can be more easily used to tag objects, and when used to tag humans or animals it can be worn with more comfort.

Pursuant to a related aspect the inventor has researched how the wearing comfort of a RFID tag structure can be increased. He has found that the ground plane can be made from a flexible material, such as a metallic mesh or a foil.

In a second aspect the present invention provides a Radio Frequency Identification (RFID) tag antenna structure comprising: a patch antenna; and a ground plane spaced from the antenna, wherein the ground plane is flexible.

In particular if the ground plane is made from a mesh it can conveniently be incorporated into a piece of clothing, thereby increasing the wearing comfort. This aspect is also provided independently.

In a third aspect the present invention provides a Radio Frequency Identification (RFID) tagging method comprising incorporating a patch antenna and a ground plane spaced from the antenna into a piece of clothing. This is of course not to be confused with the tagging of clothes in a shop, where the tag is provided externally of the piece of clothing and connected thereto by a flexible piece of plastic material or similar.

In a fourth aspect the present invention provides an object for use with a Radio Frequency Identification (RFID) tag, the object comprising a metallic structure which is integral with the rest of the object and which is arranged to increase the efficiency of a said RFID tag when used in combination with the object so as to form a Radio Frequency Identification (RFID) tag antenna structure. The metallic structure may, for example, comprise a ground plane for a patch antenna or one or more strips of metal foil or metal rods.

According to this aspect a standard RFID tag (i.e. without gain increasing metal structures such as a ground plane or director and/or reflector elements) can be mounted to the object to be tagged. This means that the standard RFID tag only needs to be handled once, which is less when compared with a technique according to which a ground plane or reflector/director element is first mounted to the RFID tag and then the RFID tag and the ground plane or director/reflector element are mounted to the object. Further, in particular if the metallic structure is moulded into the material of the object, there are fewer parts which stand proud of the surface of the object.

In a fifth aspect the present invention provides a Radio Frequency Identification (RFID) antenna structure comprising: a patch antenna; and a ground plane spaced from the antenna, wherein the patch antenna is supported and strong enough so as to withstand substantial forces in a direction perpendicular to its surface.

This is of particular use if a RFID antenna structure is required which can be placed on the ground or a floor, for example in order to detect, when connected to a tag reader, the passage of an object, a human or an animal across the ground or floor.

According to US 6,215,402 the patch antenna of the RFID tag and the ground plane are electrically connected via a circuit including a quarterwave transformer. Surprisingly, the present inventor has found that, in fact, no electrical connection between the ground plane and the antenna is necessary.

In a sixth aspect the present invention provides a Radio Frequency Identification (RFID) tag antenna structure comprising: a patch antenna; and a ground plane spaced from the antenna, wherein the ground plane is electrically insulated from the patch antenna.

Pursuant to a further aspect of the invention the present inventor has found that a YAGI type RFID tag antenna structure can be made to radiate in two opposite directions. Whilst according to US 6,278,413 a reflector element (of the same length as the driven antenna element) is placed on one side of the driven antenna element, and a (shorter) director element is placed on the opposite side of the driven element, the inventor has found that by using two director elements on opposite sides of the driven antenna element the RFID tag can be made to radiate in opposite directions.

Accordingly, in a seventh aspect the present invention provides a YAGI type Radio Frequency Identification (RFID) tag antenna structure comprising: a RFID tag; an antenna element driven by the RFID tag; and at least two director elements, at least one on each of two opposite sides of the driven antenna element, whereby the YAGI antenna is able to radiate in two opposite directions.

Apparatus aspects corresponding to method aspects disclosed herein are also provided, and vice versa.

Some preferred embodiments of the invention will now be described by way of example only and with reference to the accompanying drawings, in which:

Figure 1 shows a perspective view of a passive RFID tag antenna structure according to an embodiment of the present invention;
Figure 2 shows a perspective view of a RFID tag antenna structure for connection to a tag reader in accordance with an embodiment of the present invention;
Figure 3 shows a particular use of the antenna structure shown in Figure 2;
Figure 4 shows a YAGI type antenna structure for use in an embodiment of the present invention;

Figure 5 shows an object with integral gain increasing metallic structure according to an embodiment of the present invention; and

Figure 6 shows a bi-directional YAGI antenna structure according to an embodiment of the present invention.

Referring now to Figure 1, a first embodiment of a passive RFID tag antenna structure according to the present invention is shown. The RFID tag antenna structure 10 comprises a patch antenna 20 with a RFID tag integrated circuit 30. A ground plane 40 of metallic material is provided, which extends parallel to the patch antenna 20. The area spanned by the ground plane 40 is only slightly larger than the area spanned by the patch antenna 20. A dielectric 50 fills the space between the patch antenna 20 and the ground plane 40.

Whilst a relatively large absorbing body such as a bucket of water or a human body would absorb most of the RF power of the patch antenna without the ground plane when brought near the absorbing body, the ground plane 40 effectively shields the patch antenna 20 against absorbing bodies "behind" the ground plane 40, even if such absorbing bodies are much larger than the ground plane 40. Since the ground plane 40 is only slightly larger than the patch antenna 20 the overall dimensions of the RFID tag antenna structure are only slightly larger than those of the patch antenna 20.

According to some embodiments of the present invention the ground plane 40 can be made from a flexible material such as a mesh or a foil. This enables the RFID tag antenna structure to be worn by a human or animal with more comfort when compared with a RFID tag antenna structure with a rigid ground plane. The ground plane 40 and/or the patch antenna 20 can then be incorporated into a piece of clothing. For example, the entire RFID tag antenna structure can be sandwiched between two layers of fabric. Alternatively, a layer of fabric can be used as the dielectric 50, i.e. the layer of fabric is sandwiched between the patch antenna 20 and the ground plane 40.

In trials by the present inventor good results (in terms of range) have been obtained by using a ground plane which spans an area which is less than 2.5 times the area spanned

by the patch antenna, less than 2 times, less than 1.5 times or even less than 1.2 times the area spanned by the patch antenna.

Referring now to Figure 2, the RFID antenna structure 110 for connection to a tag reader (not shown) has a structure similar to the RFID tag antenna structure 10 of Figure 1. The RFID antenna structure 110 comprises a patch antenna 20, a ground plane 40 and a dielectric 50 as in Figure 1. Dimensions of one embodiment are shown in Figure 2 by way of example. The antenna structure 110 further includes coax cable connections 32 and 34 for connection to a tag reader. In the example shown the thickness of the dielectric 50 is only 4mm, which renders the antenna structure 110 particularly flat. It can be mounted on the ground or a floor and, due to its flat design, can easily be walked upon or driven over. The antenna structure 110 shown in Figure 2 could thus be used to control the passage of any tagged goods through the doors of a supermarket or a warehouse.

In order to enable the antenna structure 110 of Figure 2 to be walked upon or driven over, the three main components (patch antenna 20, ground plane 40 and dielectric 50) need to be made of a sufficiently strong material. The antenna structure 110 could also be covered or encased for added protection.

Figure 3 shows a further use of the antenna structure 110. As shown in Figure 3, the antenna structure 110 is attached to one of the rear portions 60 of the fork of a fork-lift truck. Again, the antenna structure 110 should be made sufficiently robust to resist any damage.

Common to all of the antenna structures 10 and 110 shown in Figures 1 to 3 is the fact that the patch antenna 20 is electrically insulated from the ground plane 40 by means of the dielectric 50. This renders the structure particularly simple and hence enables manufacture at low cost.

Figure 4 shows a YAGI type radio frequency identification tag antenna structure 200. This comprises a conventional RFID tag 210 place above a driven rod 220. A reflector

240 (which is of the same length or greater than the driven rod 220) is arranged on one side of the driven rod 220, and one or more director elements 245 are arranged at the opposite side of the driven antenna element 220. The driven element 220, the director elements 245 and the reflector element 240 are all located in the same plane. For proper tuning of the antenna structure 200 the spacing between the driven element 220 and the reflector element 240 and the director elements 245 can be determined empirically. The spacing may depend on the material which fills the space between the driven/reflector/ director elements.

As indicated in Figure 5, the structure of Figure 4 can be incorporated into an object 260 such as a plastic bucket or crate. Figure 5 shows a crate 260 in cross section. One or more of the driven antenna element 220, the reflector element 240 and the director elements 245 are moulded into the side-wall 265 of crate 260. In Figure 5 only the reflector element 240 is shown. The driven antenna element 220 and director elements 245 are located "behind" the reflector element 240, i.e. behind the paper plane. The reflector element 240, the driven antenna element 220 and the director elements 245 form an integral part of the crate 260. The crate 260 is also provided with holding protrusions 250 for receiving a RFID tag 210. This, together with the driven antenna element 220, the reflector element 240 and the director elements 245 form a YAGI antenna.

Instead of being provided externally, the RFID tag 210 could also be incorporated into the wall 265 of crate 260.

In an alternative embodiment (not shown) the side-wall 265 of crate 260 includes a metallic ground plane 40 instead of the driven, director and reflector elements. A patch antenna 20 is either mounted on the surface of the side-wall 265 of crate 260, or moulded into the material of the side-wall 265 of crate 260. The material of the side-wall 265 between the ground plane and the patch antenna effectively forms the dielectric material 50 for the patch type antenna structure.

Referring now to Figure 6, this shows a bi-directional YAGI antenna structure. The basic structure is similar to that of the embodiment shown in Figure 4. However, instead of the reflector element 240 shown in Figure 4, the Figure 6 embodiment has two further director elements 245 opposite those director elements 245 which are shown in Figure 4. The antenna structure shown in Figure 6 is suitable for radiating in both directions as indicated by bold arrows.

Although the invention has been described in terms of preferred embodiments as set forth above, it should be understood that these embodiments are illustrative only and that the claims are not limited to those embodiments. Those skilled in the art will be able to make modifications and alternatives in view of the disclosure which are contemplated as falling within the scope of the appended claims.

CLAIMS:

1. A Radio Frequency Identification (RFID) tag antenna structure comprising:
a patch antenna; and
a ground plane spaced from the antenna,
wherein the area spanned by the ground plane is not substantially larger than the area spanned by the patch antenna.

2. An antenna structure according to claim 1, wherein the area spanned by the ground plane is less than 2.5 times the area spanned by the patch antenna, preferably less than 2 times, more preferably less than 1.5 times and yet more preferably less than 1.2 times the area spanned by the patch antenna.

3. An antenna structure according to claim 1 or 2, wherein the ground plane is flexible.

4. A Radio Frequency Identification (RFID) tag antenna structure comprising:
a patch antenna; and
a ground plane spaced from the antenna,
wherein the ground plane is flexible.

5. An antenna structure according to claim 3 or 4, wherein the ground plane comprises a mesh.

6. An antenna structure according to claim 3 or 4, wherein the ground plane comprises a foil.

7. An antenna structure according to any of claims 3 to 6, wherein the ground plane is flexible to such an extent that it can be comfortably worn by a human or animal.

8. An object for use with a Radio Frequency Identification (RFID) tag, the object comprising a metallic structure which is integral with the object and which is arranged

to increase the efficiency of a said RFID tag when used in combination with the object so as to form a Radio Frequency Identification (RFID) tag antenna structure.

9. An object according to claim 8, further comprising means for receiving a said RFID tag.

10. An object according to claim 8 or claim 9, wherein the metal structure comprises a ground plane for use with a patch antenna.

11. An object according to claim 8 or claim 9, wherein the metal structure comprises a driven antenna element and/or a reflector and/or a director element for use with a RFID tag so as to form a YAGI antenna structure.

12. An object according to any of claims 8 to 11, wherein the metal structure is moulded into or onto the object.

13. An object according to any of claims 8 to 12, further comprising a said RFID tag integral with the object.

14. An antenna structure according to any of claims 1 to 7, wherein the patch antenna is supported and strong enough so as to withstand substantial forces in a direction perpendicular to its surface.

15. A Radio Frequency Identification (RFID) antenna structure comprising:

a patch antenna; and

a ground plane spaced from the antenna,

wherein the patch antenna is supported and strong enough so as to withstand substantial forces in a direction perpendicular to its surface.

16. An antenna structure according to claim 14 or 15, being placed on the ground or a floor.

17. An antenna structure according to claim 16, being able to be walked upon or driven over without suffering any substantial damage.

18. An antenna structure according to claim 14 or 15, being placed at a rear portion of the fork of a fork lift truck.

19. An antenna structure according to any of claims 14 to 18, wherein the spacing between the antenna and the ground plane is between 3 and 5 mm, preferably about 4mm.

20. An antenna structure according to any of claims 1 to 7 or 14 to 19, wherein the ground plane is electrically insulated from the patch antenna.

21. A Radio Frequency Identification (RFID) tag antenna structure comprising:

a patch antenna; and

a ground plane spaced from the antenna,

wherein the ground plane is electrically insulated from the patch antenna.

22. A Radio Frequency Identification (RFID) tagging method comprising incorporating a patch antenna and a ground plane spaced from the antenna into a piece of clothing.

23. A method according to claim 22, wherein the patch antenna and ground plane is as defined in any of claims 1 to 7, 14, 15 or 21.

24. A YAGI type Radio Frequency Identification (RFID) tag antenna structure comprising:

a RFID tag;

an antenna element driven by the RFID tag; and

at least two director elements, at least one on each of two opposite sides of the driven antenna element, whereby the YAGI antenna is able to radiate in two opposite directions.

25. An antenna structure according to any of claims 1 to 7, 14 to 21, or 24, being operable at UHF frequencies.

26. An antenna structure according to any of claims 1 to 7, 14 to 21, or 24, being operable at 869 MHz.

27. An antenna structure, an object or a method, substantially as any one herein described with reference to, or as illustrated in, the accompanying drawings.

ABSTRACT

RADIO FREQUENCY IDENTIFICATION TAGGING

A patch antenna type RFID tag antenna structure has a ground plane spaced from the patch antenna so as to increase the range of the tag. The ground plane is not substantially larger than, and electrically insulated from, the patch antenna. The ground plane is flexible, so the RFID tag structure can be worn by a human, and can be incorporated into a piece of clothing.

An RFID antenna structure for use with a tag reader is made flat and robust so that it can be mounted on the ground to be walked upon or driven over.

A bi-directional YAGI type RFID tag antenna structure has director elements on two opposite sides so that the YAGI antenna radiates in two opposite directions.

An object includes a gain increasing metallic structure for increasing the gain of a RFID tag when placed near the object so as to form a RFID tag antenna structure.

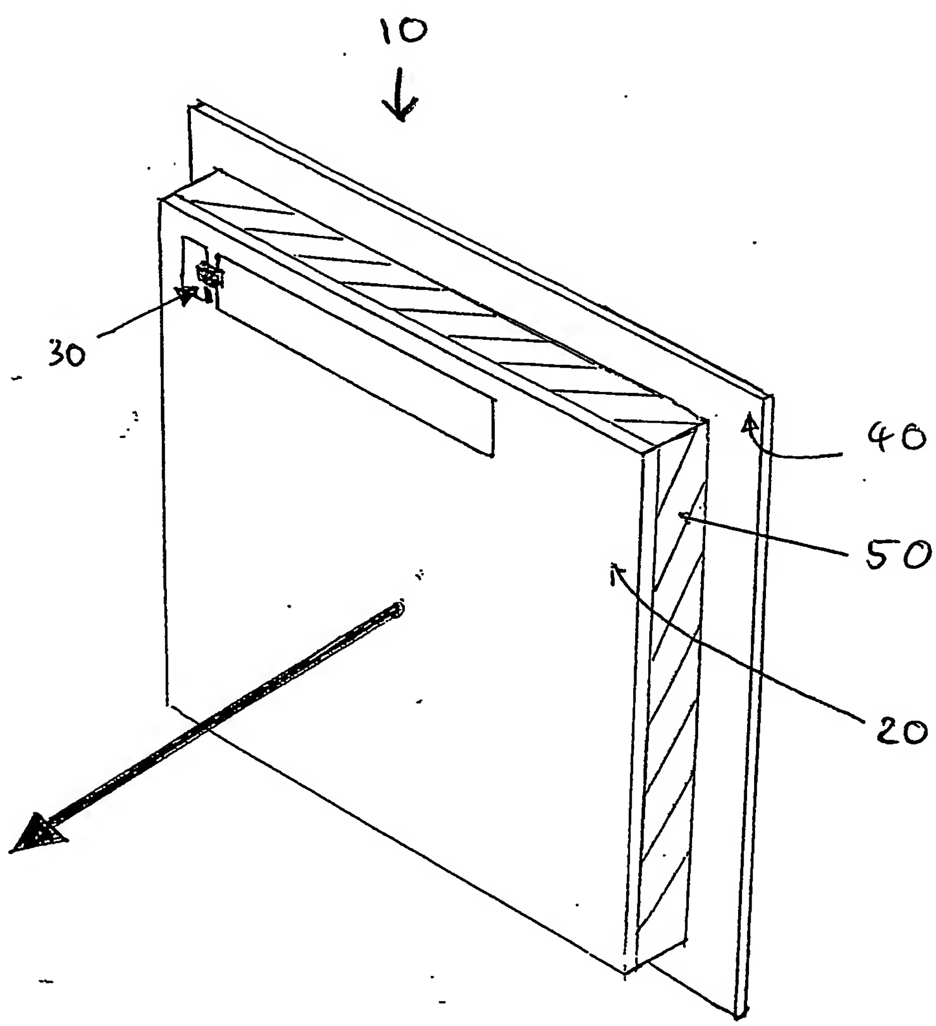

FIG. 1

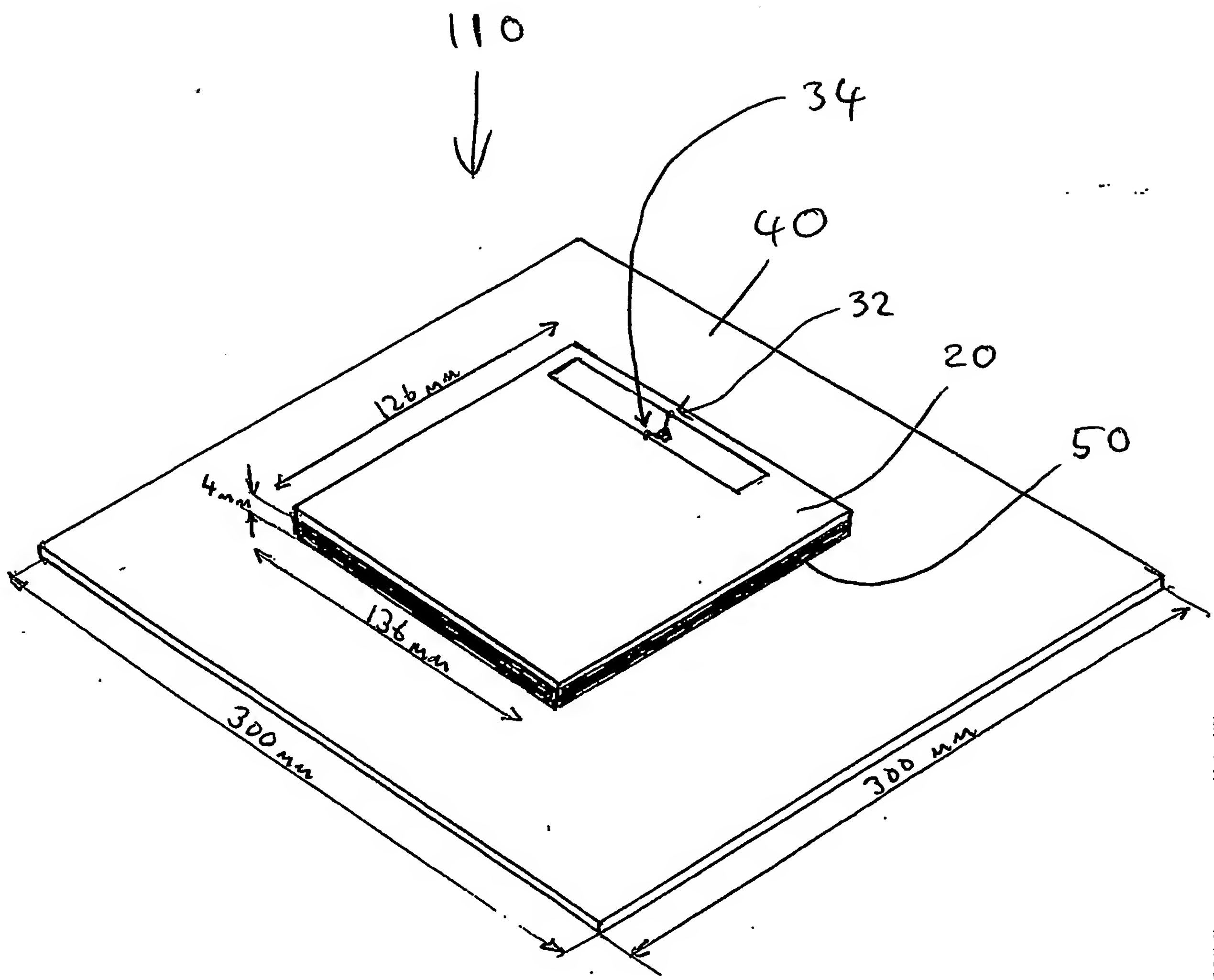

FIG. 2

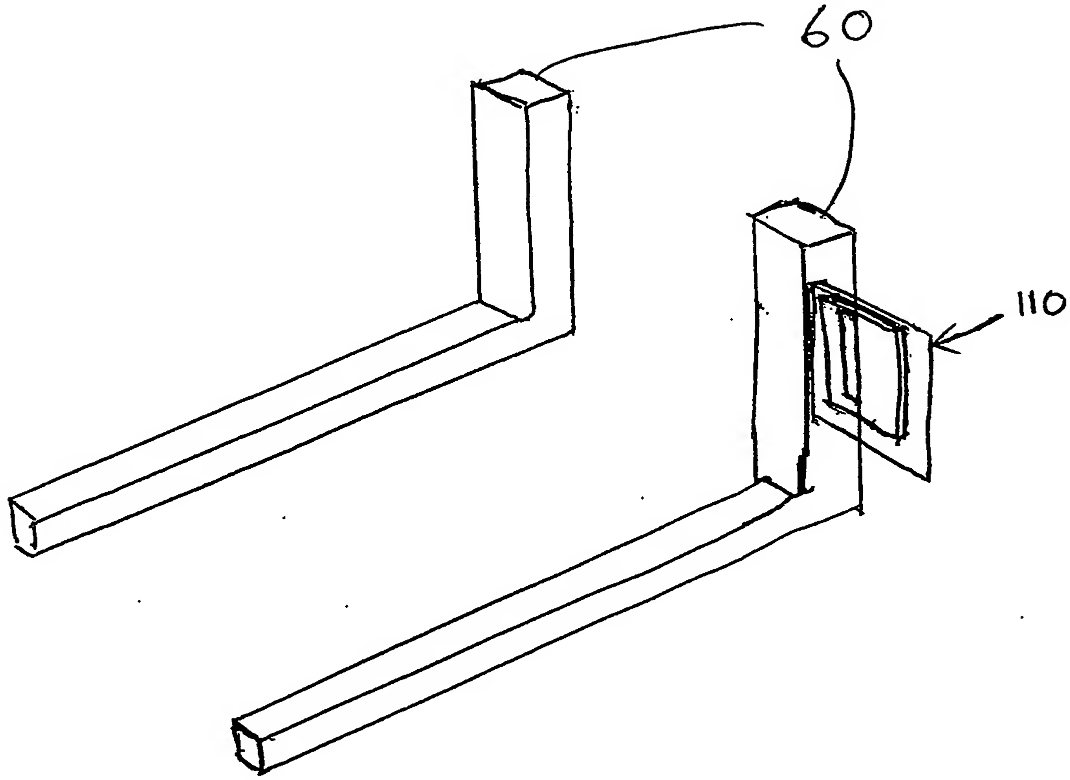

FIG. 3

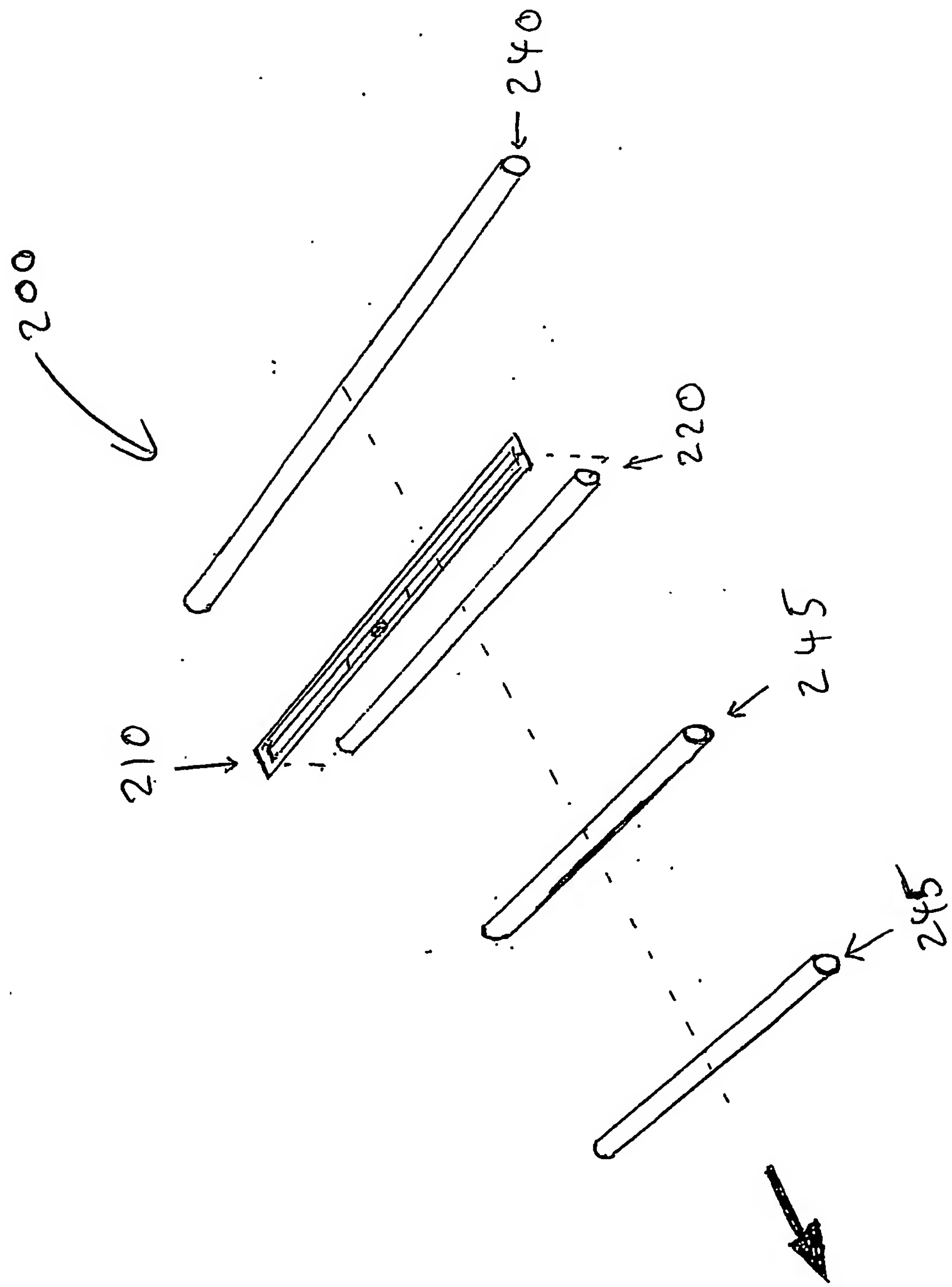

FIG. 4

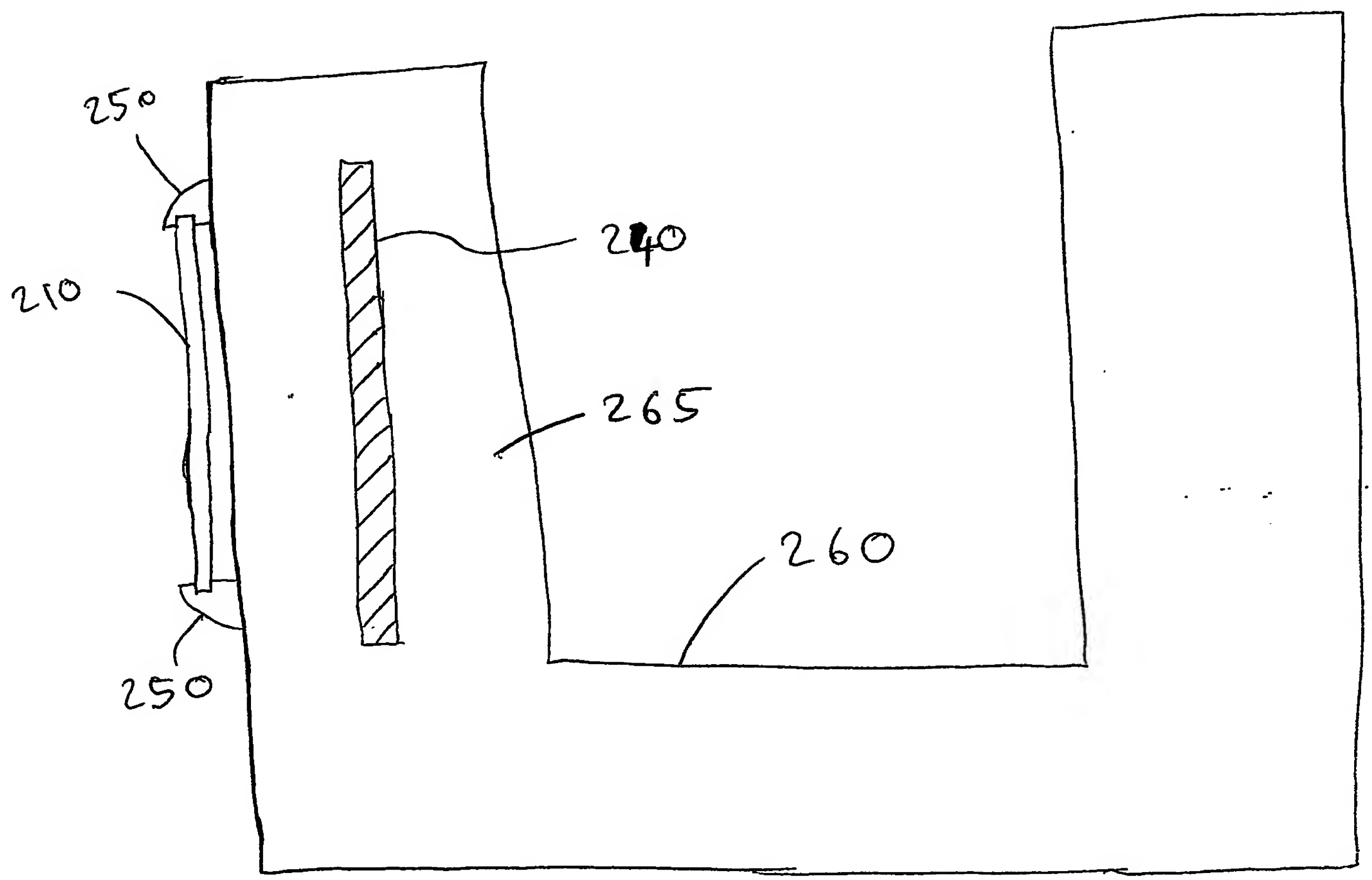

FIG. 5

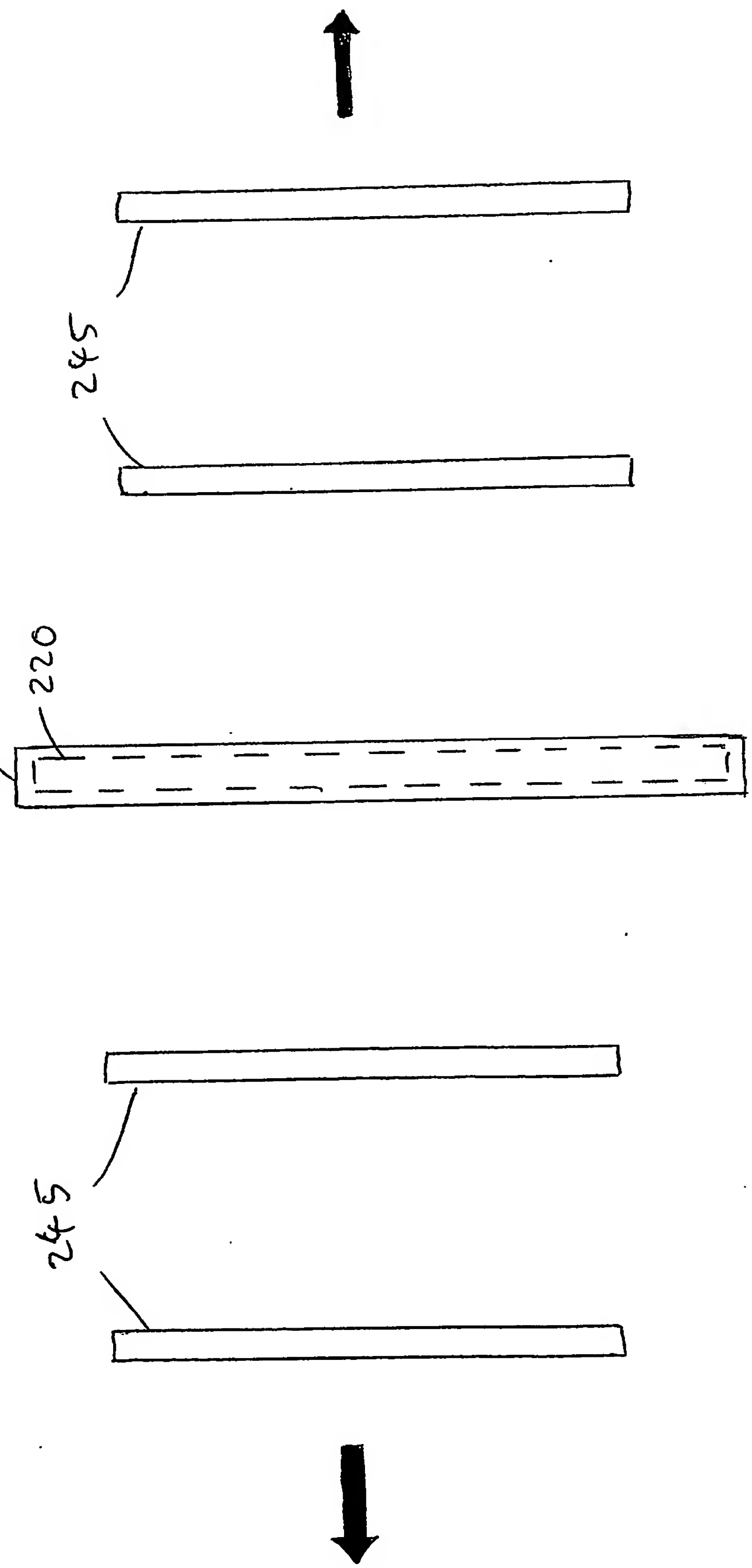

FIG. 6